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them. These peoples, like all those on the great African plateau, illustrate anew the truth, that all aborigines are adjusted to their surroundings as accurately and efficiently as the fauna and flora, in whose midst they dwell. They are the survivors who have proven their fitness to live and to people the land.

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## TOPOLOGY, TOPOGRAPHY AND TOPOMETRY

BY

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The recent discussion in the "Annales de Géographie" between Prof. Paul Girardin and Général Berthaut on the concepts of Topology, Topography, and Topometry,\* following upon the publication of Berthaut's two-volume work entitled "Topologie," seems of sufficient importance to deserve being brought to the attention of American geographers, topographers, and engineers. In this country we still content ourselves with the single term "topography," applying the same rather loosely, and in some respects inaptly, to different classes of work. The truth is that we have not yet come to separate sharply in our minds the three closely allied concepts for which the French have already for several years found it desirable to employ different terms.

The topographic map work carried on in this country, principally by the government, is recognizedly of a high order, and appreciation of its merit has been repeatedly expressed by European topographers. Nevertheless, the fact remains that we have in the United States no distinct "topographic profession," nor anything resembling a formulated science of topography. With us, topographic mapping, however excellent its results, is little more than a specialized class of surveying and drafting, and our topographers do not, on the whole, lay claim to being anything further than specially trained surveyors and draftsmen. To those familiar with the trend of geologic, and more especially of geographic science, in this country, however, it must be clear that if the topographer intends in the future to keep step with the geologist and the geographer; if the mapmaker's work

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\*Paul Girardin, *Topologie et Topographie. A propos de l'ouvrage de Gén. Berthaut, Ann. de Géogr.* Vol. XX, Nov. 15, 1911, pp. 385-395.

Gén. Berthaut, *Topologie, Topographie et Topométrie, ibid.*, Vol. XXI, Jan. 15, 1912, pp. 73-80.

is to continue adequately to meet the constantly more exacting requirements of the map user, then the time is not far distant when the former will have seriously to consider placing his work on a higher and more scientific plane. It will not suffice for him merely to keep on increasing the accuracy of his measurements and the skill of his hand. However essential surveying control, so-called, and drafting skill may be, they are not the "Alpha and Omega" of topographic mapping. What the topographer will have to do, sooner or later, is to acquire an insight into the nature of land forms, and to systematize this knowledge so that it will provide him with a definite basis for the planning of the engineering parts of his work. It is only in this way that he will be able to furnish without fail, or without preliminary and costly experimenting, the data required in any instance with the precision demanded and yet with true economy.

It was with this idea in mind that the writer, some six years ago, addressed himself to the task of working out, at least tentatively, a general groundwork upon which such a system of rationalized topography might be built. An essential part of that groundwork appeared to be a classification of detail forms, "topographic units," as the writer has frequently called them ("Einzelförme," is the German word), the delineation of which constitutes the topographer's principal work. An outline of this classification he presented before the Association of American Geographers, at the Baltimore meeting, under the title of "The Topographer's A B C of Land Forms."

It occurred to him at the outset that this study, although resting chiefly on physiography, constitutes a field of inquiry distinct from that science and not to be confused with it. It is inherently a topographer's study, and its object is a purely topographic one. In seeking a name by which to designate the new science, the desirability at once suggested itself of finding a term that might stand in apposition to that of "topography," which denotes the corresponding art. "Topology" manifestly was the logical word, but when the writer opened the Century Dictionary to see if the term might possibly be in use elsewhere, what was his dismay to discover that "topology" stands for "the art or method of assisting the memory by associating the thing, or subject, to be remembered with some place." Considering the term definitely preempted, he closed the book with a sigh and began to look in other directions for a convenient word,—thus far, however, without success. One may imagine his delight, therefore, upon finding upon his desk one day two ponderous tomes in French proudly bearing the one-word title "Topologie," and treating of the very science for which he had himself selected that term.

"A la bonheur!" he exclaimed, "that settles it!" We may incur the wrath of the mnemonician by thus appropriating his term, perhaps, but what of that, there are not many of him in the land. Besides, it is not the first instance on record of a term being used in utterly different meanings by separate sciences whose provinces are so widely remote from one another that there cannot possibly ever be a clash.

In the meanwhile "topologie" has been in use among French topographers these ten years, and bids fair to stay. Let us hope it may. There is need of such a term. The new science for which it stands, but barely out of the egg, needs careful nurturing, and the first step required to establish it and secure it recognition is to give it a name coupled with a definition. Berthaut's definition, as given in the foreword to his work on "Topologie," is: "Nous entendons par *topologie* l'étude raisonnée des formes topographiques;" the analytical study of topographic forms, to give a close translation. This he hastens to amplify by saying that the land forms referred to are not those larger ones constituting broad areal units of geographic importance, but those minor ones whose delineation requires fairly large scales of mapping, topographic scales rather than geographic scales. Topology is essentially a detail study, which, while it may be conceived to lie within the province of physiography (*géographie physique*, as it is termed in France), nevertheless comprises a separate field having a specific object. In his reply to Girardin, Berthaut states what that object is: "The principal object of topology, as conceived by the Service Géographique de l'Armée, is to furnish the topographer with the analytical elements of the forms of the relief, for the more thoroughly these forms are understood by the topographer the more successful will he be in their delineation. Reciprocally, the better the land forms have been delineated by a topographer, who knew how to bring out their characteristics, the more valuable will his topographic document be in shedding light upon the nature of the relief, the underlying structure, the erosional forces to which these structures have been exposed, etc.—all information of an implicit sort, which will be eagerly seized upon by those able to read it."

To all this the present writer promptly responds with a hearty, loud amen! His own experience has abundantly proven the soundness of Berthaut's contentions. No topographer who would aspire to give maximum value to his work, can hope to do so if he lacks an intelligent insight into the nature of land forms. Let there be no illusion on this score; the lack of intelligent understanding on the part of the uninformed delineator speaks from every line he draws;

it betrays itself in the meaningless, wooden forms that characterize his sketches, in the evident crudeness of his conceptions of nature's work. These defects may pass unnoticed by the undiscerning, but they are nothing short of galling to those to whom every curve and flexure in a contour has a meaning,—and it is just these who in their own research most rely upon and most heartily appreciate good topography.

A few topographers there are, no doubt, with whom an understanding of the relief is intuitive, but with the rank and file such is certainly not the case. For them, the only way to acquire an understanding is by patient study and close observation. Unfortunately, hitherto, there has been no book treating the subject of topographic forms in a manner specially designed to meet their needs. Well-meaning attempts have been made in this country, at one time or another, to supply the topographer with lessons in pure geology. But geology is not what he needs, and the aforesaid attempts have only resulted thus far in intensifying his prejudice against that science, a prejudice that may be likened to the loathing displayed by high school girls to algebra and other studies which they instinctively feel to be foreign to and useless in the sphere of their future activities. It is sincerely to be hoped, now that Berthaut's "*Topologie*" has given a new impetus to the study of land forms by French topographers, that a similar work may soon appear on this side of the Atlantic for the inspiration of American topographers. Such a work might well go one step further than Berthaut's, and, besides explaining the genesis of the different topographic types, attempt to lay down some principles governing the generalizing and simplifying of minor details, not fully delineable on small scale maps. How this generalizing is to be effected, and how far it is to be carried in any instance, are problems that inevitably confront the topographer who is working on much reduced scales; indeed, they are among the most perplexing problems with which he has to deal. Thus far he has been left to solve them for himself, but the unsatisfactoriness of the result must be obvious to any one who has noted the wide diversities in style of treatment so often characterizing maps drawn by different men. In topographic delineation, as in writing, generalizing is largely a matter of judgment not amenable to rigid rule, and there must always be some room for the expression of individuality. But this is not equivalent to saying that it is impossible to minimize these differences in treatment, or that it is utterly useless, as some would claim, to try to formulate principles that will tend to unify the practice. On the contrary, the divergence

in judgment shown by different delineators plainly indicates that the topographic art is still largely on an empirical basis, that its fundaments have not yet been worked out, and that much could be done to guide the individual in his judgment. As a matter of fact there do exist certain basic principles for the generalizing of topographic details on maps of different scales, and it is high time that they be announced, so that there may be a uniform understanding of them among all topographers.

There are those, no doubt, who will reply to all this that topographic mapping, in the end, is nothing but a matter of engineering, and that the topographer merely need multiply his measurements in order to obtain a representation that will be accurate and reliable throughout. But this view rests upon a misconception, a failure to distinguish between maps, the limitations of whose scales preclude the rendering of the relief feature for feature, down to the merest minutiae, and those large-scale maps upon which not merely all features can be delineated in detail, but upon which these features are measured in with mathematical accuracy, practically nothing being "sketched in" by eye. The French have long since recognized the desirability of differentiating between these two classes of maps, designating the latter "topometric maps," while reserving for the former the old term "topographic maps." Topometric maps, accordingly, are maps of high precision. The contour lines upon them are in many instances run out individually by instrumental methods, and the forms of the land are treated in the same rigorous fashion as roads, fences and other cultural features. Indeed, such maps are little else than high-grade surveyor's plats, aiming to furnish a representation of the ground sufficiently accurate for the planning of engineering works and the making of preliminary estimates. They are, of course, prepared on relatively large scales, such as 1:20,000, 1:10,000, 1:1,000 and larger.

Clearly such maps belong to a different category from those properly called topographic, whose aim it is to portray considerable areas of land with their characteristic configurations. These do not pretend to be exact replicas of the relief in miniature,—rather, they partake of the nature of abstracts,—generalized statements serving to bring out essentials, at the sacrifice, purposely, of irrelevant detail. Among the most familiar examples of this type of map are the topographic atlas sheets issued by the U. S. Geological Survey (special large-scale maps, such as those of the Yazoo Basin in Mississippi, for instance, excepted, to which the term topometric rightfully applies). The scales of the atlas sheets are for the most part 1:62,500,

1:125,000, 1:250,000, but there are a few instances where larger scales have been used, such as 1:48,000, 1:31,680, and 1:24,000. In Europe the prevailing scales are 1:20,000, 1:50,000, 1:100,000, and 1:200,000.

It stands to reason that there can be no sharp line of demarcation between topographic and topometric maps; the two naturally grade into each other. There is often a little topographic sketching on a topometric map, as in the more rugged portions of the large-scale Sacramento Valley sheets; again, there is of necessity much topometric work involved in the preparation of a high-grade topographic map. Nevertheless the distinction is a useful one, and could it only become as firmly rooted in the minds of our geographers and engineers, as it is with their French brethren, the haziness of ideas still prevailing in this country on the subject of topographic mapping would soon be dispelled. There would come to be a truer appreciation of the difference in status of the two kinds of map work and of the two professions which they represent. It would become clear, on the one hand, that topometry is essentially a branch of engineering, involving surveying and drafting of a specialized sort, and that the value of a topometric map is to be gauged primarily by its quantitative exactness. It would be recognized, on the other hand, that topography is something more than engineering, requiring for its best results a technical equipment far beyond the training surveyors or draftsmen ordinarily command. There would cease to be any further illusion about the province of topography, which is the presentation of topographic facts in condensed form; nor about its nature, which is in part that of an interpretative and synthetic art. Finally, it would be granted that there can be no hope for anything like uniform and systematic delineation until the science of land forms—topology—has been formulated and all topographers alike shall be schooled in its principles.

Whether or no we care to adopt in this country the two new terms topology and topometry, we shall hardly err in taking cognizance of the concepts for which they stand, and in thus vitalizing our own thought in the domain of topography and topographic science.